5.—ON UPPER CRETACEOUS (MAESTRICHTIAN) AMMONOIDEA FROM WESTERN AUSTRALIA.

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The occurrence of late Cretaceous ammonites (referred to the Upper Senonian or Campanian) in the northwestern part of Western Australia (Cardabia Range) has only recently been recorded by Dr. H. G. Raggatt (1), and the determinations of the ammonites (by so competent an authority as Dr. F. W. Whitehouse of the University of Brisbane), suggested the presence of a fauna of considerable importance. I was very interested therefore to hear from Dr. C. Teichert of the University of Western Australia that he had made collections of ammonites from the same beds in 1938 and I gladly accepted his kind offer to have the fauna sent to me for study. For since I (2) first discussed comparable ammonites from Africa and their allies of the Ariyalur and Valudayur Beds of India, our knowledge of the late Cretaceous successions has been greatly extended. I was also anxious to see whether the recent great multiplication of ammonite zones in the higher Cretaceous of Japan modified our views of the successions in India, Australia and elsewhere.

There are 43 ammonoids in the collection before me and they came (in about equal numbers) from the west (locality B) and south-west (locality A) sides of Remarkable Hill, Cardabia Station. The map attached to Dr. Raggatt's account gives the position of this hill as about 85 miles due south of North West Cape, and from his geological data it may be seen that the ammonites occur (with coprolites and many foraminifera (3)) in a five-feet band of glauconitic sand or sandstone. This bed is overlain by sandy, white to yellow, polyzoan limestones, 85 feet in thickness, which have yielded *Ostrea vesicularis* and other fossils, dated by Dr. Whitehouse as Campanian; and the ammonite bed is underlain by *Inoceramus* Marls that contain a fauna said to be similar to that of the Gingin Chalk. The age of the latter is approximately indicated by the presence of *Uintacrinus* and *Marsupites* (Santonian and Campanian), but the ammonites known from that deposit (4) are not suitable for exact dating. While the age of the ammonite bed was thus roughly determined it seemed that the succession was too incomplete to help

(1) Geology of North-West Basin, Western Australia, etc. *Jour. Roy. Soc. N.S. Wales*, vol. lxx., pt. 1, 1936, pp. 160-161.

(2) On Cretaceous Cephalopoda from Zululand. *Ann. S. Afr. Mus.*, vol. xii., pt. 7, No. 16 (May, 1921): On Upper Cretaceous Ammonoidea from Pondoland. *Ann. Durban Mus.*, vol. iii., pt. 2 (August, 1921): The Senonian Ammonite Fauna of Pondoland. *Trans. Roy. Soc. S. Afr.*, vol. x., pt. 3 (1922).

(3) See Irene Crespin: Upper Cretaceous Foraminifera from the North-West Basin, W. Australia. *Journ. of Palaeont.*, vol. xii., No. 4, 1938, p. 391.

(4) Spath: Note on two Ammonites from the Gingin Chalk. *Jour. Roy. Soc. West. Australia*, vol. xii., 1926, pp. 53-5. There is another ammonite from the Gingin Chalk in the British Museum (Nat. Hist., Geol. Soc. Coll. No. 226) marked "near foot of Mt. Albert" (the specimen referred to in my paper on Jurassic Ammonites from Western Australia). It is crushed and very imperfect, but apparently it is also a *Pachydiscus* (*? Eupachydiscus*) like those previously discussed.

in the elucidation of the problems to which I directed attention in 1921 (1), namely the contemporaneity or otherwise of the diverse elements included in the Campanian and Maestrichtian. It will be necessary to discuss the probable sequence of the various Campanian-Maestrichtian horizons after the ammonoids have been considered in detail.

Genus **PARAPHYLLOCERAS**, Shimizu, 1935.

One example, still septate at 83 mm. diameter, and therefore representing the inner whorls of a large individual, is compared to *P. nera* (Forbes), the holotype of which is only 20 mm. in diameter. The Australian specimen is an internal cast, without trace of ornamentation, except rather closely spaced, sigmoidal folds, as in *P. surya* (Forbes). The latter has rather coarser ribbing than *P. nera* in the young, and it is less flattened laterally; but later the two species become very similar, except in the spacing of the costation. One of the syntypes of *P. surya*, in fact, at 72 mm. diameter (with body-chamber) may equally well be attached to *P. nera*, being more finely ribbed than the large example figured by Kossmat (2), but having an equal whorl-thickness (28%). Marshall (3) stated that the folds disappeared more quickly in his New Zealand form (= *P. marshalli*, Shimizu) than in *P. surya*, but in the Australian example before me, as well as in the syntype already mentioned, the folds (with or without pseudo-constrictions on the inner whorl-side in the young) persist, just as they do in *P. surya*. Since the genus *Paraphylloceras*, Shimizu (4) was proposed for the group of *P. surya* (Forbes) the closely allied *P. nera* must also be referred to that genus.

Genus **PHYLLOPACHYCERAS**, Spath, 1925.

There are two examples of *Phyllopachyceras forbesianum* (d'Orbigny) in the emended interpretation of Kossmat (5). Since this species, already recognised by Dr. Whitehouse, was referred to by him as *P.* cf. *forbesianum* he may have doubted its identity with the Valudayur form. I have before me, however, Forbes's original (B.M. No. R. 10476, Geol. Soc. Coll.) and topotypes from the Kaye and Cunliffe Collections, and there seems to be no difference either in suture-line or in dimensions; but while the beautifully preserved Valudayur specimens show the delicate ornamentation, the Australian examples are smooth, internal casts. In spite of Marshall's (6) remarks, the whorl-section is much more like that figured by Kossmat (7) than his own, misleading diagram. The suture-line, also, was incorrectly figured by the former author, and his identification of the New Zealand

(1) *Loc. cit.* (*Ann. Durban Mus.*), 1921, pp. 54 55.

(2) Untersuchungen über die südindische Kreideformation. Pt. i. *Beitr. Pal. Geol. Österr.-Ung.*, vol. ix., 1895, pl. xvi., fig. 1.

(3) *Op. cit.* (1926), p. 134, pl. 26, figs. 1-2. (The whorl-section is very misleading if the form is correctly referred to *P. nera*).

(4) See Spath: Problems of Ammonite Nomenclature VII. The genera *Paraphylloceras* and *Neophylloceras*, Shimizu. *Geol. Mag.*, 1939.

(5) Untersuchungen über die südinische Kreideformation Pt. iii. *Beitr. Pal. Geol. Österr.-Ung.*, vol. xi., 1898, p. 124.

(6) The Upper Cretaceous Ammonites of New Zealand. *Trans. N.Z. Inst.*, vol. 56, 1926, p. 136, pl. 19, fig. 6, pl. 27, figs. 3-4.

(7) *Op. cit.*, pt. 1, *Beitr. Pal. Geol. Österr.-Ung.*, vol. ix., 1895, pl. xv., fig. 1. (This form was later renamed *P. whiteavesi*, Kossmat).

form with Forbes' species may not be reliable; but Dr. Marshall was right in saying that there were twelve (external) saddles. These are followed by eight internal (dorsal) saddles, so that there are altogether eighty elements in the suture-line. It should be added that I agree with Gignoux (1) in deriving *P. forbesianum* from *P. infundibulum* and *P. rouyanum* (d'Orbigny) and therefore include it in *Phyllopachyceras*, Spath (1927) (2). According to Shimizu (3) *P. forbesianum* (of Santonian and Lower Campanian age) is succeeded by *P. ezoense* (Yokoyama), but I believe the two to be the same rather long-ranged species, or at least I can see no difference between the Japanese and Indian examples before me.

Genus **PSEUDOPHYLLITES**, Kossmat.

A septate fragment of a *Pseudophyllites* seems to have a slower rate of increase in whorl-height and thickness than the well-known Valudayur species *P. indra* (Forbes) (4). The height is 32 and 47 mm., respectively, at the two ends, the thickness 29 and 44 mm. The length along the siphonal line is just under 100 mm. and in the holotype of *P. indra* a corresponding change in dimensions appears to take place in a length of only about 80 mm. Combined with this apparent slower rate of increase in size there is a slightly less high umbilical slope, but it is difficult to tell whether these differences (in a single fragment) are of significance. The suture-line shows good agreement with that of *P. indra*, and I may mention that Whitehouse already referred a West Australian ammonite to that species.

Genus **HAUERICERAS**, Grossouvre.

A fragmentary example of an unkeeled *Hauericeras* (Plate II., Fig. 3), consisting of portions of two septate whorls, shows constrictions which are almost straight and only slightly projected peripherally as in Kossmat's (5) figure of *H. gardeni* (Baily). At a diameter of about 45mm. (reconstructed) the proportions were approximately .34-, .24-, .36, indicating a greater whorl-thickness than in *H. gardeni* which also has a less regularly oval section. The internal cast shows a siphonal groove, not deep, but very clearly marked, and it is possible that this corresponded with a keel on the test, but there is also no trace of a keel on the next inner whorl. The suture-line is that of a typical *Hauericeras*.

Stoliczka (6), who examined Forbes's original (figured) example of *Amm. durga* (B.M. No. R. 10467*a*, *b*, Geol. Soc. Coll.), thought that it was merely the young of *H. rembda* (Forbes), before the keel appeared; and I have previously (7) followed Stoliczka in identifying the two species. But the Australian example shows that there is such a species as *H. durga*, especially if Forbes's smaller second (unfigured) specimen be taken to re-

(1) Les Phylloceratidés du Paléocrétacé. *Mém. Carte géol. dét. France* (1920) 1921, p. 100.

(2) Sur quelques espèces du Gault, nommées par P. Reynès. *Ann. Mus. Hist. nat. Marseille*, vol. XX., 1925, p. 101.

(3) The Upper Cretaceous Cephalopods of Japan. I. *Jour. Shanghai Sci. Inst.*, sect. II., vol. 1, 1935, pp. 200, 201.

(4) See Kossmat, *op. cit.*, pt. i. (1895), p. 137, pl. xvi., fig. 9.

(5) *Ibid.*, pt. iii. (1898), pl. XVIII., fig. 7a.

(6) The Fossil Cephalopoda of the Cretaceous Rocks of S. India. *Pal. Indica*, ser. 3, pt. 2, 1864, p. 63: *Records Geol. Surv. India*, vol. I., 1868, p. 33.

(7) *Loc. cit.* (*Trans. Roy. Soc. S. Afr.*, 1922), p. 130.

present this form. The latter example has the constrictions rather angular on the periphery and therefore is much like any young *Hauericeras,* including the smaller syntype of *H. rembda,* though not the holotype of that species, with its very characteristic keel. Stoliczka's fig. 5 (pl. lxxi.) represents this emended *H. durga,* but not figs. 6, 7 (=*Puzosia compressa,* Kossmat) which came from the uppermost Albian Utatur Group, and therefore are not directly related to the form here discussed. *H. ugapuhi,* Marshall (1), which is also unkeeled, differs in proportions, and has a much higher umbilical wall, if the section is reliable.

Genus **KOSSMATICERAS**, de Grossouvre, 1901.

(Plate I., Fig. 2.)

There are two examples of a form which has great resemblance to *Amm. aemilianus,* Stoliczka (2) from the Aryalur Group of India, a species which was included by Marshall (3) in the separate genus *Maorites,* and by Kilian and Reboul (4) in the sub-genus *Madrasites,* whereas the similar *K. kalika* (Stoliczka), recorded by Dr. Whitehouse from Western Australia, was referred to *Gunnarites.* But the examples before me (which may quite well be identical with Dr. Whitehouse's form) are also close to *K. gemmatum* (Huppé) from Quiriquina, which was made the type of yet a third sub-genus (*Grossouvreites*) by Kilian and Reboul. The Australian form has a whorl-thickness of 33% as compared with 36% in *K. aemilianum* and 34% in *K. gemmatum,* while the width of the umbilicus is 23% (instead of 16% in *K. aemilianum* and 21% in *K. gemmatum*). As regards measurements the Australian form thus is less close to *K. aemilianum* than to *K. gemmatum* which was described by Steinmann (5) as being in some respects intermediate between *K. aemilianum* and *K. kalika.* But the ribbing at the beginning of the outer whorl in Steinmann's figure is far more distant than that of the examples before me, so that provisional reference to *K. aemilianum* is suggested, *K. kalika* showing crenulation of the ribbing. On the other hand, as Steinmann has shown, *K. gemmatum* (like the Australian form) has an incomparably more finely divided suture-line than any of the Aryalur species which is important, since *K. aemilianum* is generally recorded as from the uppermost Campanian (6).

The inner whorls of the smaller example are seen in section and they are only slightly more compressed than is the restored section given of *Holcodiscus tenuistriatus* by Paulcke (7). That species was described as less close to *Kossmaticeras gemmatum* than to *K. aemilianum,* and though the Australian and Patagonian forms are not identical, they undoubtedly are very closely related. I am recording the resemblance because Paulcke's

(1) *Loc. cit.* (*Trans. N.Z. Inst.*, vol. 56, 1926), p. 190, pl. 43, fig. 3, pl. 45, fig. 3.

(2) *Op. cit.* (Fossil Cephalopoda, Cret. Rocks, S. India), 1865, p. 141, pl. lxx., figs. 6-8.

(3) *Loc. cit.* (*Trans. N.Z. Inst.*, vol. 56, 1926), p. 174.

(4) Les Céphalopodes néocrétacées des îles Seymour et Snow Hill. *Wiss. Erg. Schwed. Südpol.-Exp.* 1901-03, vol. III., Lief. 6, 1909, pp. 25-6.

(5) Die Cephalopoden der Quiriquina-Schichten. *N. Jahrb. f. Min. &c. Beil.* Bd. X., 1895, p. 71.

(6) See e.g. Shimizu *loc. cit.* (*Journ. Shanghai Sci. Inst.*), 1935, p. 190.

(7) Die Cephalopoden der oberen Kreide Südpatagoniens. *Ber. Naturf. Ges. Freiburg* i. B., vol. XV., 1906, p. 224, pl. xvi., fig. 4.

species is from a bed higher in the sequence than the presumably Upper Campanian *Hoplitoplacenticeras* bed and succeeded only by *Baculites* wrongly attached to *B. vagina,* Forbes.

Genus **KITCHINITES**, Spath, 1922.

A septate whorl-fragment (Plate II., fig. 2) of a large ammonite (incomplete at restored diameter of about 115 mm.) from locality A, seems to differ from the much smaller *Holcodiscus karapadensis.* Kossmat (1), chiefly in size. There is the same type of costation, possibly a little coarser, in correspondence with the larger size, and the same flat and partly smooth whorl-side. The umbilical tubercles are not conspicuous, except at the very oblique constrictions, and the suture-line is similar and highly complex. But the two forms are not identical because at a diameter greater than that of the larger lectotype of *H. karapadensis,* the Australian fragment had at least a smooth venter, if not also a smooth whorl-side, as is shown by the impressed dorsal area. Moreover, the ventral chevrons of the outer whorl, directed forwards, are interrupted by a distinct siphonal groove, a feature known in certain forms of *Pachydiscus* (*e.g., P. valognensis,* Spath (2)). On the whole, the Australian ammonite is in the nature of a passage form between the Puzosidae and Pachydiscidae on the one hand and the Kossmaticeratidae on the other. The genus *Kitchinites* which is based on a species (*K. pondicherryanus,* Kossmat sp. (3)) first described as a *Holcodiscus* and considered to be nearly related to *Kossmaticeras theobaldianum* (Stoliczka), is thus undoubtedly a closer ally of the Australian form than is the more advanced *Holcodiscus karapadensis.* Until larger examples of *K. pondicherryanus* have been found, it is impossible to compare it accurately with the megalomorph form now described, but it seems to me that the latter represents the style of outer whorl that the typical (and less Puzosid) forms of *Kitchinites* must be presumed to have developed.

A second fragment, though labelled locality B, almost fits on to the first and appears to be a portion of the same ammonite.

Genus **PACHYDISCUS**, Zittel, 1884, emend. Grossouvre, 1893.

Half of a septate ammonite (Plate II., fig. 1) of about 100 mm. diameter has the whorl-shape of *P. gollevillensis* (d'Orbigny) (4), but slightly closer ribbing. It is thus much like *P. valognensis* (Spath) (5), which, in side-view, is indistinguishable from a "second example" of *P. gollevillensis* figured by A. de Grossouvre (6), but which is distinctly more compressed and more involute than the true *P. gollevillensis.* The Indian *P. crishna* (Forbes) (7) is probably an even closer ally. It is a more robust form than *P. compressus,* Spath (= *P. gollevillensis,* Kossmat (8), *non*

(1) *Loc. cit.* (part 2, 1897), p. 41, pl. viii., figs. 4a-c (lectotype), 2a, b.

(2) *Loc. cit.* (*Trans. Roy Soc. S. Afr.*, 1922), p. 122.

(3) *Op. cit.* (part 2, 1897), p. 40, pl. vi., figs. 6a-c.

(4) See in A. de Grossouvre: Les Ammonites de la Craie supérieure. *Mém. Expl. Carte géol. France,* 1893, p. 214, pl. xxix., figs. 4a, b.

(5) *Loc. cit.* (*Trans. Roy. Soc. S. Afr.*, vol. x., 1922), p. 122.

(6) *Loc. cit.* (1893), pl. xxxi., figs. 9a, b.

(7) Report on the Fossil Invertebrata from S India. *Trans. Geol. Soc.* (2), vol. vii., 1845, p. 103, pl. ix., fig. 2.

(8) *Op. cit.* (part 3, 1898), p. 97, pl. xv., figs. 1a-c.

d'Orbigny) and it differs from the Australian example in having all the ribs more distantly spaced and more prominent on the periphery, but it is equally evolute.

The portion of the next inner whorl which is preserved in the dorsal area shows a smooth periphery; and the very faint outer ribs of each side only appeared at a diameter of about 35 mm. This is the ornamentation of the young *P. egertoni* (Forbes) (1), but it is not nearly so robust as that of the immature *P. crishna,* wrongly united by Stoliczka (2) with the former. There can be no doubt that *P. egertoni* and *P. neubergicus* are not specifically identical, but they both belong to the group of *P. gollevillensis* as Matumoto (3) has recently again stated; and the compressed Australian form as well as the *P.* sp. cf. *compressus,* already recorded by Whitehouse, therefore belong to *Pachydiscus* in the most restricted sense (4).

In addition to the example of *P.* aff. *gollevillensis* (d'Orbigny) just discussed, there are in the present collection five fragments of a more inflated species of *Pachydiscus.* The thickness is constantly greater than the whorl-height (Th.: H. = 9:8) but in spite of this inflation the form is undoubtedly also a true *Pachydiscus,* for at a diameter of about 35 mm., the venter was still perfectly smooth and the secondary ribs of the ventro-lateral border appeared only at over 50 mm. The umbilical nodes were prominent, however, even in the very young stage, so far as can be seen, and at diameters of about 80 or 90 mm. they are very conspicuous, each then corresponding to about three distant secondaries. The appearance, therefore, is rather different from that of the similarly inflated *P. colligatus* (Binkhorst) (5) which has closer ribbing and loses the umbilical tubercles more quickly. The suture-line, however, is of the same type and since the internal lobes are visible in all the five specimens, I may add that the terminal prongs of the dorsal lobe are irregularly trifid. Like the inclination of the internal saddles, they can be of no systematic value, or be used to separate the inflated forms from the compressed species of *Pachydiscus* of the *neubergicus* group.

The Australian species just discussed is probably new; and I take it to be related to a gigantic form included by Stoliczka (6) in his *Amm. ootacodensis,* but renamed by Kossmat (7) *P. grossouvrei.* Unfortunately the inner whorls of this form are not known and those of its presumable European ally *P. wittekindi* (Schlüter) (8) are generally deformed by pressure,

(1) *Loc. cit.* (*Trans. Geol. Soc.*, 2, vol. vii.), 1845, p. 108, pl. ix., fig. 1.

(2) *Loc. cit.* (*Pal. Indica,* ser. 3, pt. 5), 1864, p. 104, pl. liii., fig. 4.

(3) Contributions to the Cretaceous Palaeontology of Japan. I. Preliminary Notes on the So-called *Parapachydiscus egertoni* (Forbes) from Japan. *Jap. Jour. Geol.,* 1936, p. 262.

(4) Spath: Problems of Ammonite Nomenclature. VI. The Genus *Pachydiscus.* Zittel. *Geol. Mag.,* 1939.

(5) See in Grossouvre: Descriptions des Ammonitidés du Crétacé supérieur &c. *Mém. Mus. Roy. Hist. nat. Belgique,* vol. iv., 1908, pls. iv., v. and vi. only.

(6) *Loc. cit.* (*Pal. Indica,* ser. 3, pt. 6), 1865, p. 109 (pars), pl. lvii. only.

(7) *Op. cit.* (Part 3), 1898, p. 101.

(8) Cephalopoden der oberen deutschen Kreide. Lief II. *Palaeontogr.*, vol. xxi., 1872, p. 67, pls. xxi and xxii (as *Amm. robustus*). If the young original of Pl. xxi., figs. 1-2 is correctly identified with the large lectotype of this species (*ibid.*, figs. 5-6), *P. wittekindi* acquires ventral ribs at an earlier stage than the Australian form, but the drawing is almost certainly unreliable (especially in the umbilical ribbing).

so that direct comparison is difficult. The Australian form may be somewhat intermediate between the *P. ootacodensis* and *P. ianjonaensis,* Collignon (1), recently described from Madagascar; but it is not the same author's *P. grossouvrei,* nor is it a form of *Eupachydiscus* in which genus the projected ribs may be strong or enfeebled on the venter, but are not interrupted in the siphonal line or thickened on each side of the venter.

Genus **DIPLOMOCERAS**, Hyatt, 1900.

There are four straight and septate fragments (smooth, internal casts) of an almost cylindrical species of *Diplomoceras* which must have reached considerable dimensions, the largest fragment having a ventro-dorsal diameter of about 55 mm. (and a lateral diameter of only 2 or 3 mm. less). The lytoceratid suture-line with its high external lobe is that of the very similar *D. cylindraceum* (Defrance) d'Orbigny sp. (2), in which the internal casts also show no trace of the ornamentation. While the four fragments here discussed might thus easily have been referred to the French species, there is a fifth, slightly curved fragment, apparently with an identical suture-line, which suggests caution in identifying the Australian form. For the last fragment, with a cylindrical cross-section, though largely a smooth cast, bears traces of the costation which was not only far more prominent and sharper than that of *D. cylindraceum,* but which was strongly oblique, the dorsal side being considerably retracted. The unusual sharpness of the ribs, however, may be due to the weathering (and replacement by limonite) and one of Schlüter's (3) examples of *Hamites cylindraceus* also shows strongly oblique ribs. Moreover, in a fine Vancouver specimen of *D. notabile* (Whiteaves) in the British Museum (No. C3486), while the internal cast is quite smooth, only the inner layer of test has the peculiar low and flattened ribs often seen in *Diplomoceras* (and well shown in d'Orbigny's figure), and the outermost layer shows rather sharper ribbing. Something similar is seen in a large fragment figured by Kossmat (4), which was wrongly attached to *Glyptoxoceras rugatum* (Forbes) and which may well be a portion of a *Diplomoceras.*

Genus **GLYPTOXOCERAS**, Spath, 1925.

There are apparently three or four species of this genus (which includes the so-called *Anisoceras* of the Valudayur Beds of India), but they are represented only by five body-chamber fragments, no trace of a suture-line having been observed.

The first species (Plate I., fig. 1) is represented by a straight portion 87 mm. long, which is slightly bent at the larger end, like comparable fragments from Pondicherry in the British Museum. The costation is blunt and distinctly oblique; there are seven ribs in a length equal to the diameter and there is very little attenuation of the ribbing on the dorsal side. The section is slightly compressed, the thickness being 19.5 mm. where the height = 21 mm. This fragment is probably close to *G. rugatum* (Forbes) (5) and dif-

(1) Ammonites campaniennes et maestrichtiennes de l'O. et du S. de Madagascar. *Ann. géol., Service des Mines,* fasc. ix., 1938, pl. ix., figs. 2, 4.

(2) *Pal Francaise, Terr. Crét.,* vol. i., 1842, p. 551, pl. cxxxvi.

(3) *Op. cit.,* Lief. v., 1872, pl. xxxi., fig. 10.

(4) *Op. cit.* (part i.), 1895, p. 146, pl. xix., fig. 8 (part only and rather diagrammatic; B.M. No. 10501, Geol. Soc. Coll.).

(5) *Loc. cit.* (*Trans. Geol. Soc.,* 2, vol. vii.), 1845, p. 117, pl. xi., figs. 2a-c.

fers chiefly in the inclination of the ribs; but this may be due to its being a body-chamber whereas the holotype of Forbes's species, refigured by Shimizu (1), is septate.

A second fragment has slightly less blunt and less oblique ribbing and is therefore still closer to *G. rugatum*. The attenuated costation of the dorsal side is slightly projected forward (in the form of a feeble sinus) whereas in the first fragment the dorsal ribs are regularly concave. The height is 20mm. where the thickness = 17mm., as in the holotype of Forbes's species, and what appears to be the apertural end is more distinctly bent than in the larger fragment first described. Neither, unfortunately, retains the final collar. The second example may not be definitely identifiable with *G. rugatum*, because it is so incomplete, but if I am right in associating it with a third fragment that retains its sharp ribbing, specific identity is almost certain.

In a fourth example, about 70mm. long and as slightly compressed as the other three, the ribs are more distantly spaced (five in a length equal to the diameter). In the large holotype fragment of *G. largesulcatum* (Forbes) (2) the ribbing is still more distant, but there are syntypes (in the Kaye and Cunliffe Collections) which scarcely differ from the Australian example; nor does one of Stoliczka's (3) examples of *G. largesulcatum*, representing part of the spiral portion like the fragment here discussed. *G.* (?) *nipponicum*, Shimizu (4), based on a *Hamites* sp. figured by Jimbo (5) and referred by Kossmat (6) to *G. largesulcatum*, differs chiefly in its circular section.

The last example of *Glyptoxoceras*, also a hook about 60mm. long, may be compared to *G. subcompressum* (Forbes) (7), although the ribbing is somewhat less close (seven ribs in a length equal to the diameter, instead of eight). The fragment is slightly malformed, the costae of one side being flexuous, but the compressed section and the sharpness of the ventral ribbing are characteristic.

Genus **EUBACULITES**, Spath, 1926.

The group of *E. vagina* (Forbes) (8) is well represented, but while there are many very typical specimens of that group, there is nothing quite like Forbes's holotype (B.M. No. 10488, Geol. Soc. Coll.). The original drawing is incorrect in so far as the nodes are placed too near the double-edged ventral side. In reality, there is a longitudinal groove, which separates the smooth ventral from the nodate dorsal half of the side, and it is situated almost as near the middle of the shell, as in d'Orbigny's (9) figure of *Baculites ornatus* which is generally taken to be a synonym of *E. vagina*. Since Forbes's drawing shows the entire tabulate venter the narrowness of the smooth zone is particularly misleading. In the Australian forms which are here compared to *E. vagina*, there is no more trace of a longitudinal groove, or separation of the side into two different areas or zones, than there is in

(1) The Upper Cretaceous Ammonites so-called *Hamites* in Japan. *Proc. Imp. Acad. Tokyo*, vol. xi., 1935, p. 273, text-figs. 1-5.

(2) *Loc. cit.* (*Trans. Geol. Soc.*, 2, vol. vii.), 1845, p. 117, pl. xi., figs. 1a-c.

(3) *Loc. cit.* (*Pal. Indica*, ser. 3, pts. 10-13). 1866, p. 180, pl. lxxxv., fig. 8.

(4) *Loc. cit.* (*Journ. Shanghai Sci. Inst.*), 1935, p. 199.

(5) Beiträge zur Fauna der Kreide von Hokkaido. *Pal. Abh.*, vol. vi., 1894, p. 40, pl. vii., fig. 7.

(6) *Op. cit.* (part i.), 1895, p. 147.

(7) *Loc. cit.* (*Trans. Geol. Soc.*, 2, vol. vii.), 1845, p. 116, pl. xi., fig. 6.

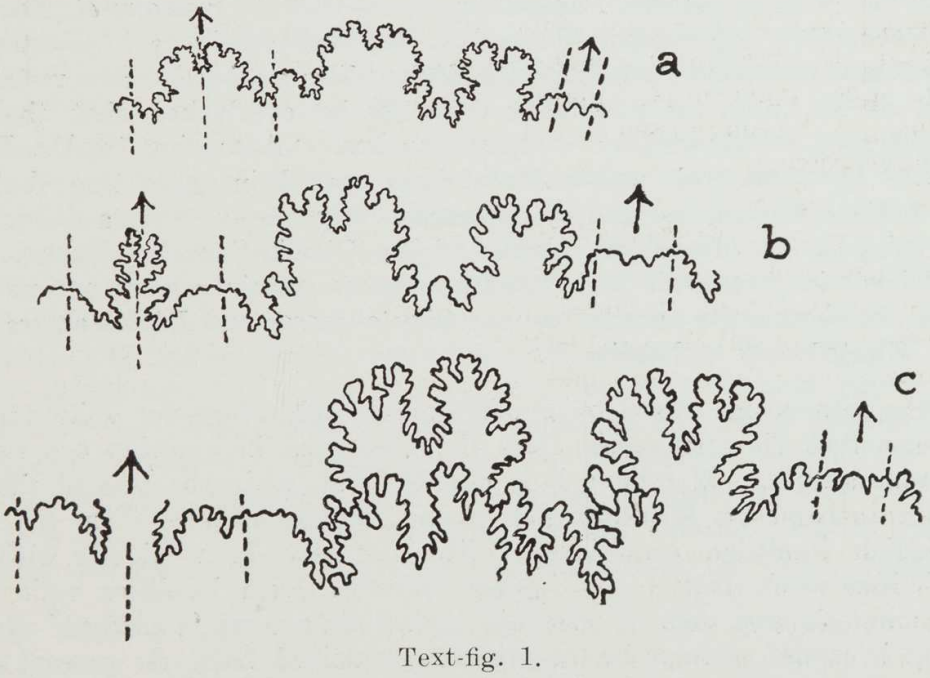
(8) *Ibid.*, p. 114, pl. x., fig. 4.

(9) Voyage de l'Astrolobe, etc., 1847. Atlas Pal., pl. iii., figs. 3-6.

E. otacodensis (Stoliczka) (1), but the spacing of the crescentic nodes is closer even than in Forbes's type (about ten in a length of 90mm., as against nine in *E. vagina*) There is some variation, however, in the strength of the crescents, one example having them as prominent as in *E. otacodensis,* while two larger fragments are almost smooth. Some examples are curved as much as Forbes's type and the suture-line seems to be rather variable, especially as regards the prongs in the siphonal saddle on the tabulate venter. According to Steinmann (2) this median saddle bears a characteristic, deep funnel-shaped siphonal incision, and this is distinct enough in some of Darwin's South American forms before me; but in the Australian specimens under discussion, a bifid incision as in Forbes's type of *E. vagina* (Text-fig. *a.*) is commoner than a single prong, while in at least one fragment there are three equal incisions in the middle of the siphonal saddle.

E. otacodensis is represented by three typical examples, one of them represented in Plate I., fig. 3; its suture-line is reproduced in Text-fig. *b*. A variety of presumably the same form (with concave dorsum) shows nodes that do not come up to the dorsal edge and thus are more rounded and less prominent. The fragment of a gigantic individual (long diameter = 60mm.) and still septate (see Text-fig. *c.*), may belong to the same form, but if so, it has lost the ribs almost completely, like the two large fragments above referred to as *E.* aff. *vagina.*

Three small examples agree with Kossmat's (3) *E. simplex* which is separated specifically from *E. vagina* because it is a passage-form between *Eubaculites* and *Baculites* s.s.



Text-fig. 1.

Tracings (natural size) of Suture-lines of *Eubaculites.*

(*a*) *E. vagina* (Forbes) holotype (B.M., No. 10488, Geol. Soc. Coll.), Pondicherry, S. India. (*b*) *E. otacodensis* (Stoliczka). No. 20138, Dep. Geol. Univ. West. Aust., from Remarkable Hill (locality B), Cardabia Station, W. Australia, figured in Plate I., fig. 3. (*c*) *E.* sp. ind. Very large example, No. 20146, Dep. Geol. Univ., West. Aust., from the same bed (locality A).

(1) See especially in Kossmat, *op. cit.* (part i., 1895), p. 157, pl. xix., fig. 16.

(2) Die Cephalopoden der Quiriquina-Schichten. *N. Jahrb. f. Min,* etc. *Beil.* Bd. x., 1895, p. 91.

(3) Kossmat, *op. cit.* (part i., 1895), p. 156, pl. xix., fig. 13 (lectotype = *Baculites vagina,* var. *simplex*).

STRATIGRAPHICAL RESULTS.

The forty-three ammonoids described in the foregoing pages belong to the following sixteen species:—

A *Paraphylloceras* aff. *nera* (Forbes).
A *Phyllopachyceras forbesianum* (d'Orbigny).
B *Pseudophyllites* cf. *indra* (Forbes).
A *Hauericeras durga* (Forbes). (Plate II., fig. 3.)
*A *Kossmaticeras* sp. nov. ? aff. *aemilianus* (Stoliczka). (Plate I., fig. 2).
(?) *Kitchinites* sp. ind. (Plate II., fig. 2.)
B *Pachydiscus* aff. *gollevillensis* (d'Orbigny). (Plate II., fig. 1.)
*A, B *Pachydiscus* sp. nov. ? cf. *grossouvrei,* Kossmat.
B *Diplomoceras* aff. *cylindraceum* (Defrance) d'Orbigny sp.
B *Glyptoxoceras rugatum* (Forbes).
B *Glyptoxoceras* cf. *rugatum* (Forbes). (Plate I., fig. 1.)
B *Glyptoxoceras* aff. *largesulcatum* (Forbes).
B *Glyptoxoceras* cf. *subcompressum* (Forbes).
A, B *Eubaculites* aff. *vagina* (Forbes).
*B *Eubaculites otacodensis* (Stoliczka). (Plate I., fig. 3.)
*B *Eubaculites simplex* (Kossmat).

When I first examined this fauna I did not think that there was any difference between the forms from locality A and the assemblage from B, but it will be seen from the above list that the two localities have only two species in common, namely, *Pachydiscus* sp. nov. ? cf. *grossouvrei,* Kossmat, and *Eubaculites* aff. *vagina* (Forbes). The former belongs to a comparatively long-lived genus; and although *Eubaculites vagina* is more restricted, so far as we know, the possibility must not be overlooked that the two assemblages are not strictly contemporaneous. According to Dr. H. G. Raggatt (1) field-work and palaeontology agreed in suggesting that the same horizon was represented by the ammonite greensand over a distance of fifty miles along the eastern slopes of the Giralia-Cardabia Range. Yet the deposit is glauconitic and therefore almost certainly more or less condensed; moreover, the uncoiled genera *Glyptoxoceras* and *Diplomoceras* have been collected only at locality B.

The assemblage named by Dr. Whitehouse also does not quite support the view that the ammonoids from the greensand in question are strictly contemporaneous. Of course, it is possible that, as in the case of the differences noticed by Wilckens (2) among the assemblages from his three Quiriquina localities, conditions of life may have been slightly different. Dr. Whitehouse's fauna may include elements from localities rather far apart; but, in any case, it was said to include several "unnamed" genera, so that it cannot perhaps be too critically examined from our present point of view. Yet while *Parapachydiscus* (now *Pachydiscus*) cf. *compressus,* Spath, and *Gunnarites kalika* (Stoliczka) are probably near enough to *Pachydiscus* aff. *gollevillensis* and *Kossmaticeras* sp. nov. aff. *aemilianus,* of the above list respectively, to suggest approximate contemporaneity, and while three more forms (*Phyllopachyceras forbesianum* (d'Orbigny), *Pseudophyllites* cf. *indra* (Forbes), and *Eubaculites* aff. *vagina* (Forbes)) occur

(1) *Loc. cit.* (Jour. Roy. Soc., N.S. Wales, vol. lxx.), 1936, p. 160.

(2) Revision der Fauna der Quiriquina-Schichten. *N. Jahrb. f. Min.* etc. *Beil.* Bd. xviii., 1904, p. 273.